AN AUTOMATED LASER INSPECTION SYSTEM FOR AVLB

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1. Introduction

Tactical bridging is a key component in ensuring mobility of the future combat system for a successful assault operation. The US Army has several rapidly deployable mobile bridging systems in its inventory including over 900 Armored Vehicle Launched Bridges (AVLB). Currently, reliability of these bridging assets is ensured through extensive visual inspections to detect defects and subsequent maintenance of these assets. However, visual inspection is time consuming and subjective in nature without reliable early crack detection capability.

An accurate and efficient Nondestructive Evaluation (NDE) algorithm based on vibration parameters using a strain energy approach and laser vibrometry has been developed by the Constructed Facilities Center, West Virginia University (CFC-WVU) in conjunction with Litton Laser Systems and the US Army. A unique Automated Laser Vibration Sensor System (ALVSS) was developed, designed and fabricated for automated vibration testing of large structures such as an AVLB.

2. Technical Approach

It is known that damage in a structure can be characterized in terms of flexural stiffness loss at a cross section. Research at CFC-WVU has shown that damage can be located and quantified using the dynamic strain energy distribution (Venkatappa, 1997). The dynamic strain energy distribution is evaluated along a structure using vibration test data and is defined between two arbitrary points a~b as:

$$U_{ab} = \frac{1}{2}\int_a^b EI(\phi)^2 (\phi'')^2 \, dx \qquad (1)$$

where,

- U_{ab} = strain energy calculated over the zone ranging from ‘a’ to ‘b’
- EI = flexural rigidity of the cross section (assumed constant)
- ϕ = mode shape vector
- ϕ'' = modal curvature

The strain energy damage detection approach locates damage in a structure given its mode shape information before and after damage. The sensitivity of the damage detection approach is dependent on the number of actual pick up points. Traditional contact sensors such as accelerometers provide data with limited spatial density (i.e., limited number of data points measured on a structure), non-contact sensors such as a scanning laser vibrometer can provide spatially dense data thereby improving the damage detection capability using the strain energy approach. However, off the shelf laser sensor systems were not suitable to test the AVLB therefore a prototype ALVSS was designed and custom built.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **00 DEC 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **An Automated Laser Inspection System For Avlb**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Constructed Facilities Center, College of Engineering and Mineral Resources West Virginia University, Morgantown, WV**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2004 in Orlando, Florida., The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**2**	

3. Automated Laser Vibration Sensor System

An automated laser vibration sensor system was custom built to automate the entire vibration testing process of the AVLB so that the vibration output data could be directly integrated with the strain energy damage detection algorithm. The sensor system consists of five parts: 1) Automated robotic gantry, 2) laser vibrometer, 3) data acquisition/signal generation hardware, 4) excitation mechanism, and 5) a control program written in LabVIEW (Aluri et al 2002).

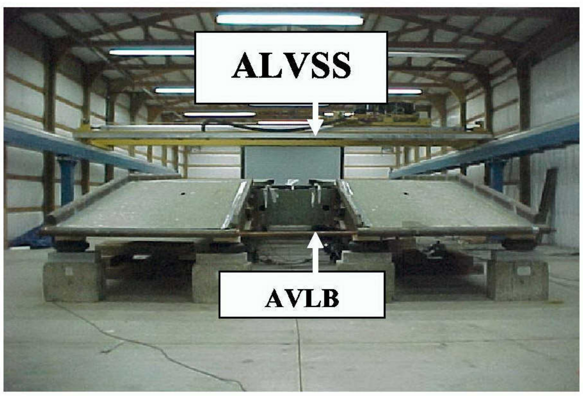

Figure 1. Testing of AVLB using ALVSS

4. Test Results and Conclusions

Full scale vibration tests were conducted on the undamaged AVLB to establish a baseline response. Four damage scenarios were simulated on the AVLB and tests were conducted for each damage case using the Automated Laser Vibration Sensor System (Figure 1). These tests were conducted as proof-of-concept/system tests. The acquired vibration responses from the test were processed using the strain energy algorithm. Damage was successfully located in two of the four damage scenarios. Two other damage scenarios were not detected since those damage scenarios resulted in minimal reduction of overall stiffness of AVLB. Researchers at CFC have also developed a nonbaseline damage detection method which does not require the baseline response for damage detection.

5. Potential Impact

The strain energy algorithm and ALVSS used in conjunction have reduced the time needed for inspecting AVLBs. Furthermore, the vibration based damage detection method has higher reliability and repeatability for testing all the AVLBs and other mobile bridging assets in service with the US Army which can ensure a safer operation of these bridging assets in the theater of operations.

Acknowledgements

The authors wish to acknowledge the financial assistance provided by the US Army for this research under the contract DAAE07-96-C-X226.

References

Venkatappa, S.G., 1997: "Damage Detection Using Vibration Measurements," *thesis submitted to Department of Civil and Environmental Engineering at West Virginia University, Morgantown, WV.*

Aluri, S., Sazonov, E., GangaRao, H. V. S., Petro, S. H., Klinkhachorn, P., 2002: "Automated Laser Sensor System," *Proceedings Structural Materials Technology V, An NDT Conference*, Cincinnati, Ohio, p173-190.